A MODEL OF THE SUBSURFACE STRUCTURE AT THE RYE PATCH GEOTHERMAL RESERVOIR BASED ON SURFACE-TO-BOREHOLE SEISMIC DATA

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RESEARCH OBJECTIVES

Berkeley Lab has cooperated with The Industrial Corporation (TIC) and Transpacific Geothermal Inc. (TGI) in studies to evaluate and apply modern seismic-imaging methods for geothermal reservoir definition under the DOE's Geothermal Program. As part of this cooperation, a 3D seismic-surface survey was acquired in 1998, at the Rye Patch Reservoir, Pershing County, Nevada, to determine the structure of the reservoir (Feighner et al., 1999). During the 3D survey, an additional experiment was conducted during which a three-component geophone was installed in a borehole at depth. This geophone recorded all seismic waves generated by the surface sources, creating a second dataset in addition to the seismic reflection data. The second dataset was used to map variations in the reservoir horizon within the area of the reservoir.

APPROACH

A high-temperature, wall-locking, three-component geophone was installed in Well 46-28 at 3,900 ft depth. The borehole geophone recorded all shots throughout the survey area, amounting to a total of 2,134 traces. The data quality is good, with a frequency content of about 25 Hz for the first arriving waves. A total of 2,005 first-arrival travel times were determined out of the 2134 possible traces. Most of the picks were reliable because the well-sampled spatial moveout across the source lines facilitated the picking.

Mapping travel-time deviations to elevation changes is a technique that has been used in seismic-refraction studies in the past. The method is an approximation that can be applied in environments where a low-velocity layer is located above a high-velocity layer or basement. Under the assumption that the ray path from source to receiver is known, any difference between the calculated and observed travel times is converted into a distance using the velocity model and applied as a deviation in the boundary between the basement and the overlaying layer. We employ the same principle in our approach and derive a velocity model of the subsurface at the Rye Patch Reservoir from a vertical seismic profile (VSP) that was conducted in 1997 (Feighner et al., 1998). Based on this velocity model, travel times are computed for each ray path from source to receiver, and the differences in the observed travel times are converted to elevation changes. In our case, we apply the total travel-time difference for each ray to the whole geologic model, thus assuming that any possible faulting affected the whole geologic sequence above the basement.

ACCOMPLISHMENTS

A mapview of the basement horizon elevation is provided in Figure 1. Three boreholes (46-28, 44-28, and 42-28) are shown for reference. It can be seen that the 0 ft elevation contour line runs through Well 46-28, which is expected since the velocity model is based on the VSP data acquired in that well. Only a small deviation between the modeled and measured data is expected at this location. The map shows the contours of an elevated structure extending from east to west across the survey area. The north-south extent of this rise reaches roughly from 2107000 (north of well 42-28) to 2102000 (between Wells 46-28 and 44-28), while the east-west extension seems to reach beyond the boundaries of the survey area (Figure 1). The elevation in the reservoir could be described by a horst or a ridge structure bound by two east-west trending faults to the north and south. The interpretation of an elevated basement with an east-west trend, bounded by linear features towards the northern and southern extension, is in agreement with 2D tomographic results (Feighner et al., 1999) and possibly with geophysical investigations undertaken in a previous study (Teplow, 1999).

RELATED PUBLICATIONS

Feighner, M.A., T.M. Daley, and E.L. Majer, Results of the vertical seismic profiling at Well 46-28, Rye Patch Geothermal Field, Pershing County, Nevada, Berkeley Lab Report LBNL-41800, 1998.

Feighner, M., R. Gritto, T.M. Daley, H. Keers, and E.J. Majer, Three-dimensional seismic imaging of the Rye Patch Geothermal Reservoir, Berkeley Lab Report LBNL-44119, 1999.

Teplow, B., Integrated geophysical exploration program at the Rye Patch Geothermal Field, Pershing County, Nevada, Final Report to Mount Wheeler Power, 1999.

ACKNOWLEDGMENTS

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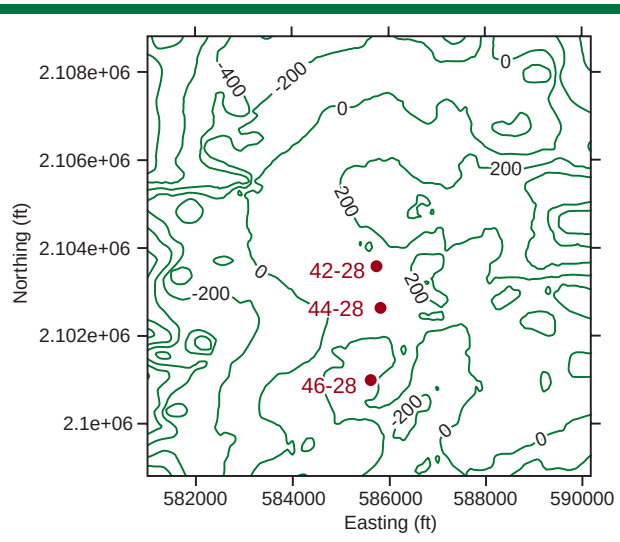

Figure 1. Contour map of the variations in elevation of the basement interface at the Rye Patch Geothermal Reservoir. The boreholes are indicated for reference.